IceCube & SWIRP

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Cloud Ice Sensitivity Gap

$$T_{cir} = T_b - T_{b\_clear}$$

- Clouds, ice clouds in particular, are a major source of uncertainty in climate models

- Submm-wave sensors fill the sensitivity gap between MW and IR.

- Cloud microphysical properties (particle size and shape) account for large (~200% and 40%) measurement uncertainty.

Cloud Ice Sensitivity Gap

PDF ×10³

Ice Water Path (IWP) from CloudSat/CALIOP
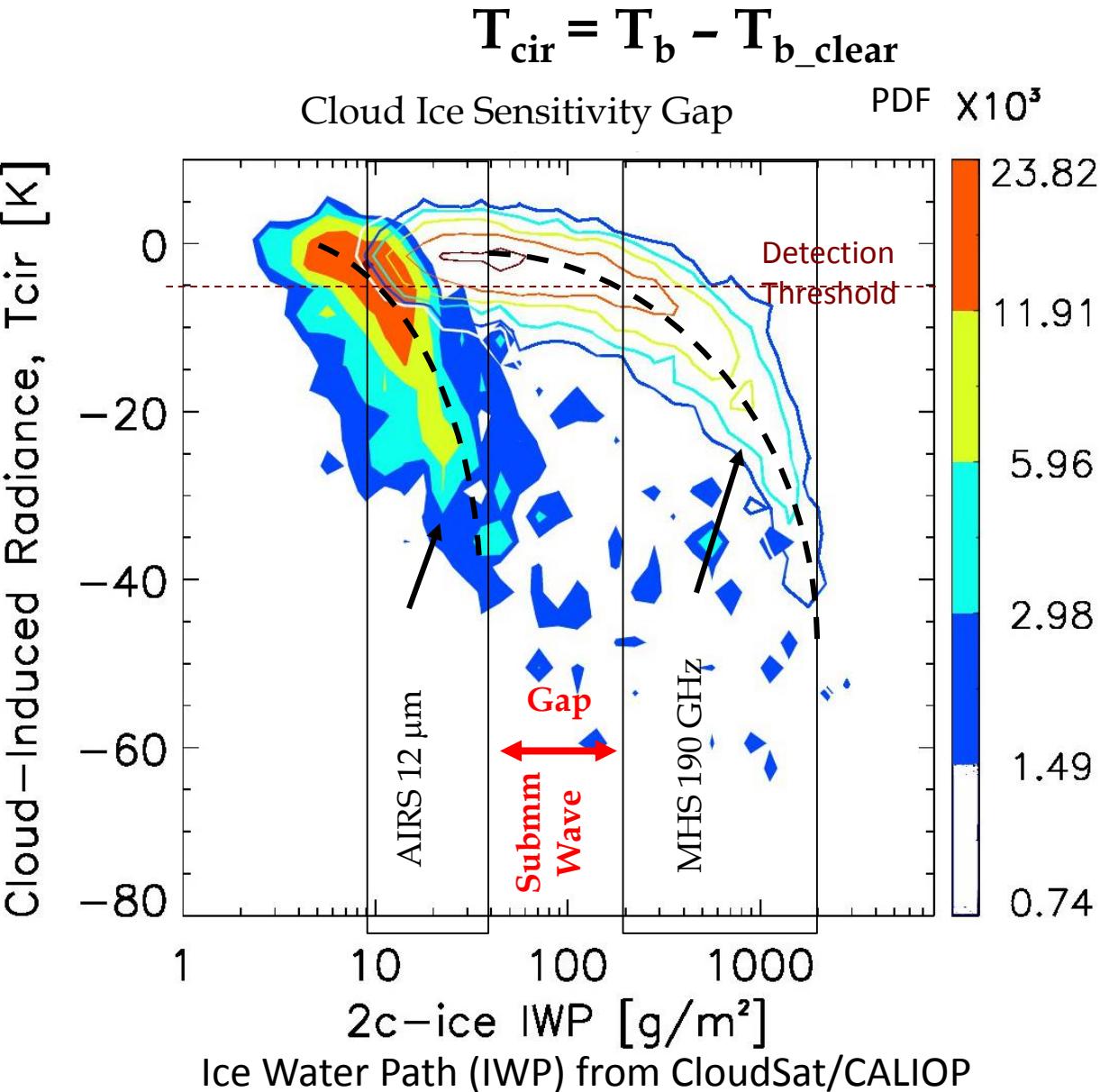
Motivations

IceCube

- Submm-wave cloud radiometer to fill cloud ice gap in the atmosphere

- Spaceflight demonstration of a commercial 883-GHz receiver for technology maturation (TRL 5->7)

- Utilization of emerging cubesat platform for space access and fast development cycle
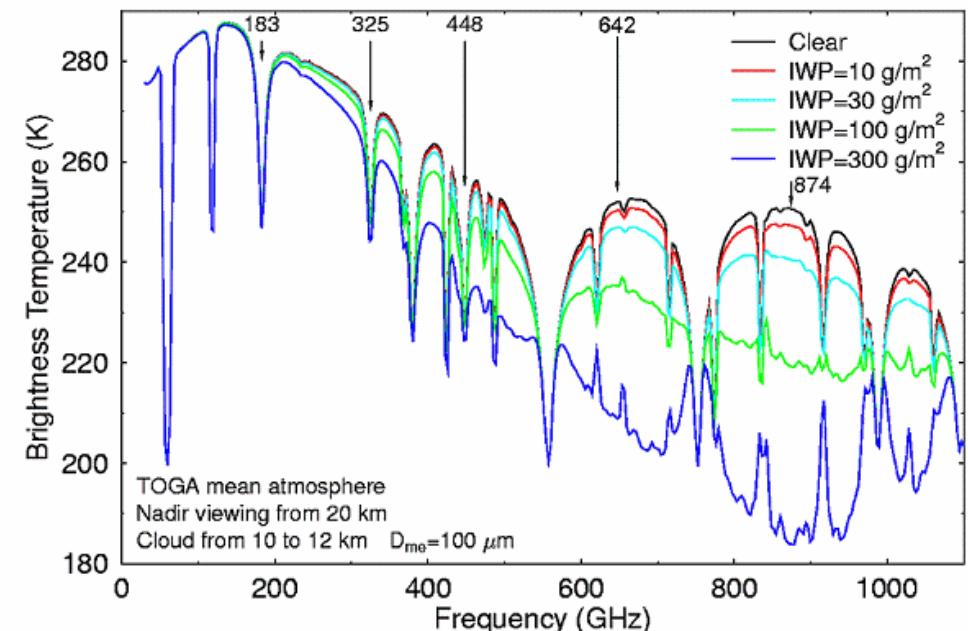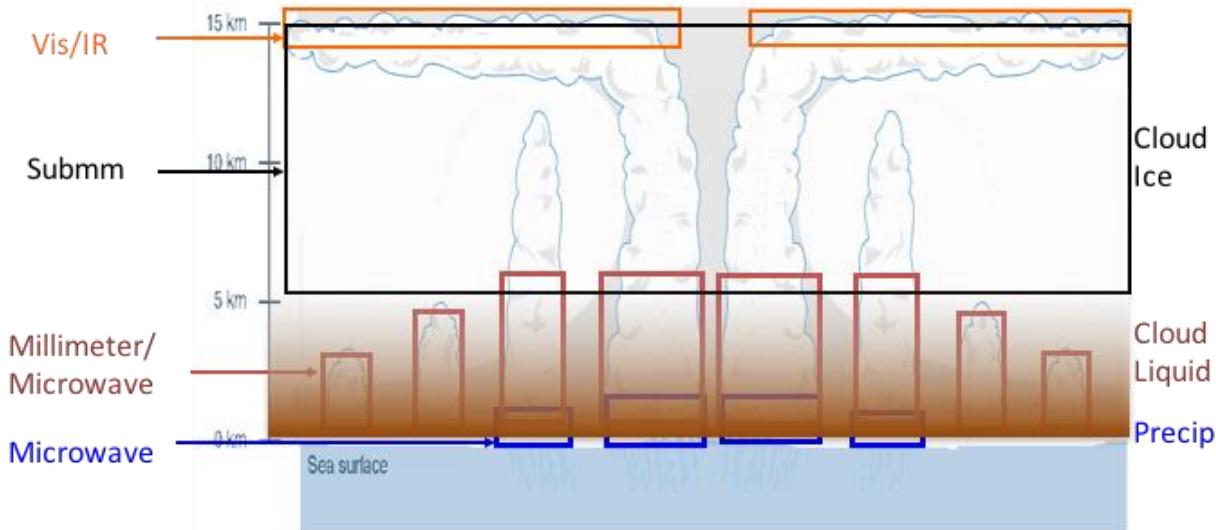
IceCube's Journey to Space

- 04/2014   Project start
- 04/2016   Payload delivered
- 12/2016   Delivery to NanoRacks (cubesat launcher)
- 4/19/2017   Launched to ISS
- 5/16/2017   Jettisoned from ISS and contacted at WFF
- 6/6/2017   First light
- 6/9-18:19:49   IceCube within 23m from CubeSat HOOPEO
- 6/18-7/20   Daytime-only observations
- 7/17/2017   First 883-GHz cloud radiance map
- 8/2-present   Daytime-only observations

IceCube Operation
Spacecraft spins around the Sun vector. Initial operation is restricted to daytime observation only.
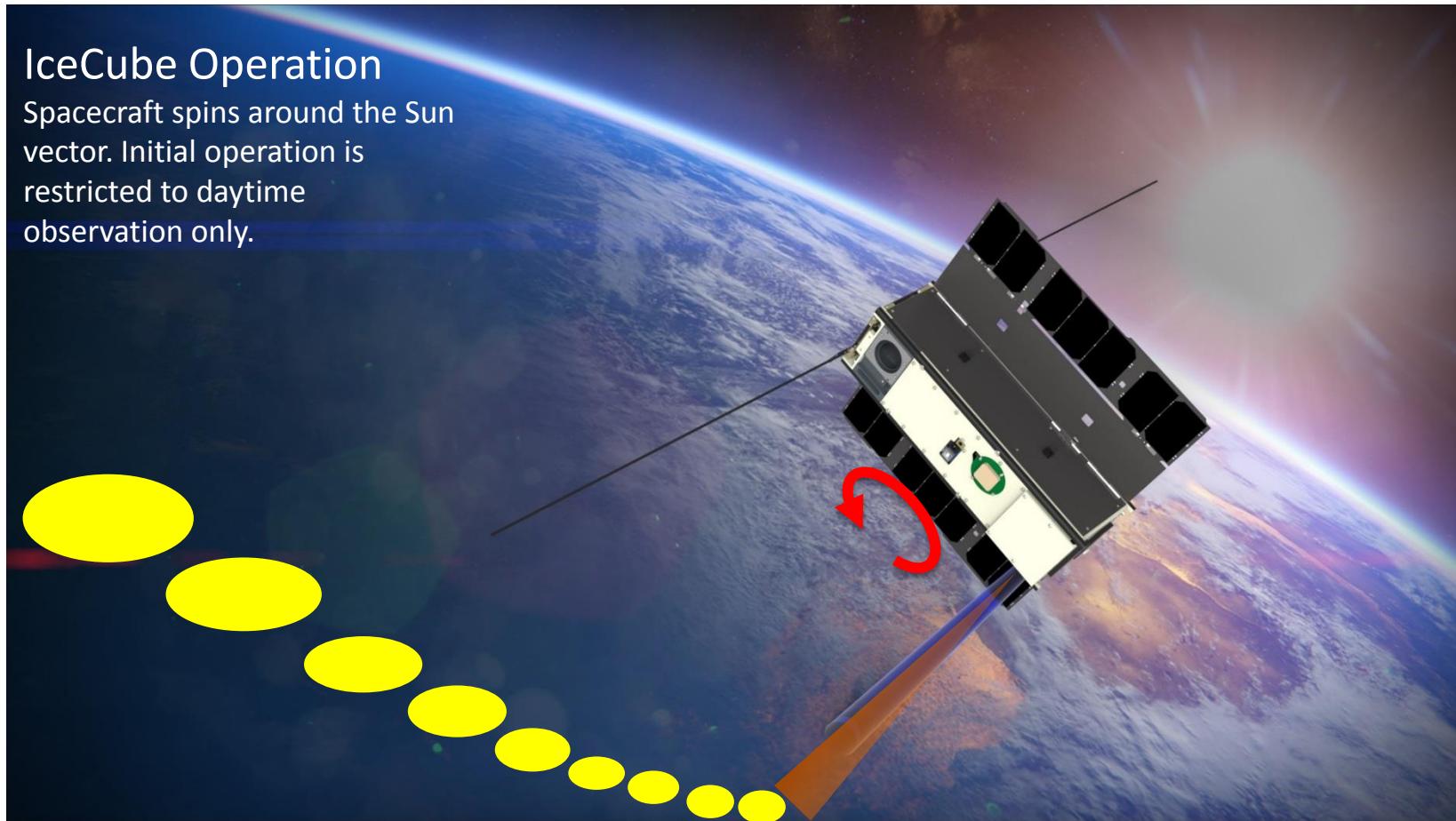
CubeSat Internal Layout

Total

Mass:	4 kg
Volume:	3 U
Power:	18 W
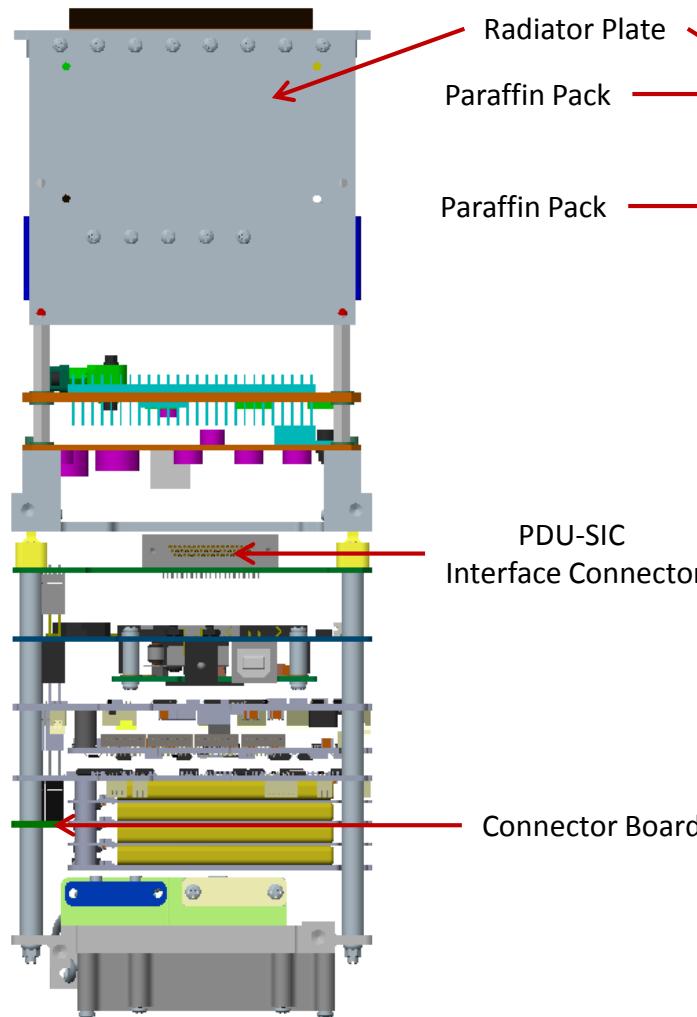
Instrument:

Mass:	1.0 kg
Volume:	1.3 U
Power:	5.6 W

Radiator Plate

Paraffin Pack

Paraffin Pack

PDU-SIC
Interface Connector

Connector Board

Paraffin Pack

Instrument MLA Assembly

Instrument IFA Assembly

Instrument RIC

Instrument PDU

Spacecraft Interface Card (SIC)

Pumpkin Motherboard

Pumpkin Processor

Clyde Space EPS

Clyde Space Battery Pack (40whr)

Novatel GPS Receiver

L3 Cadet Radio
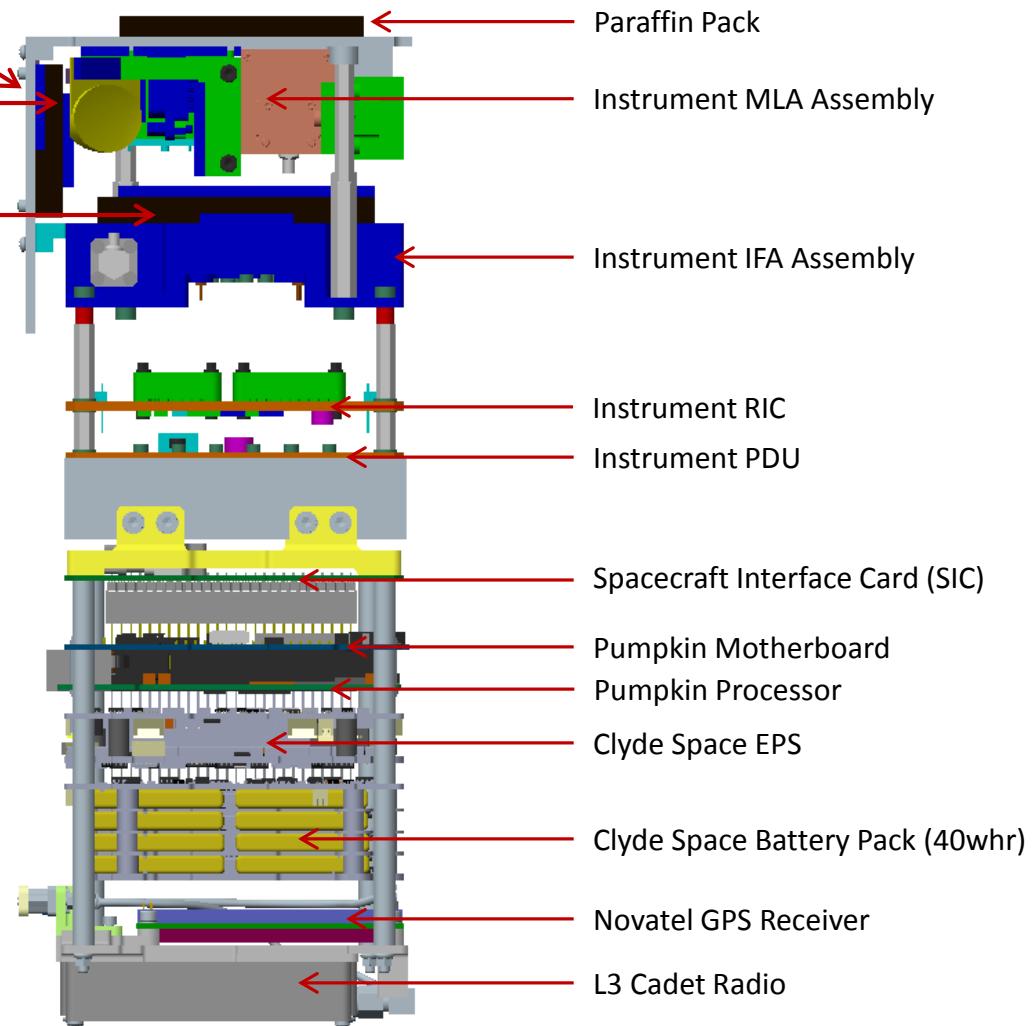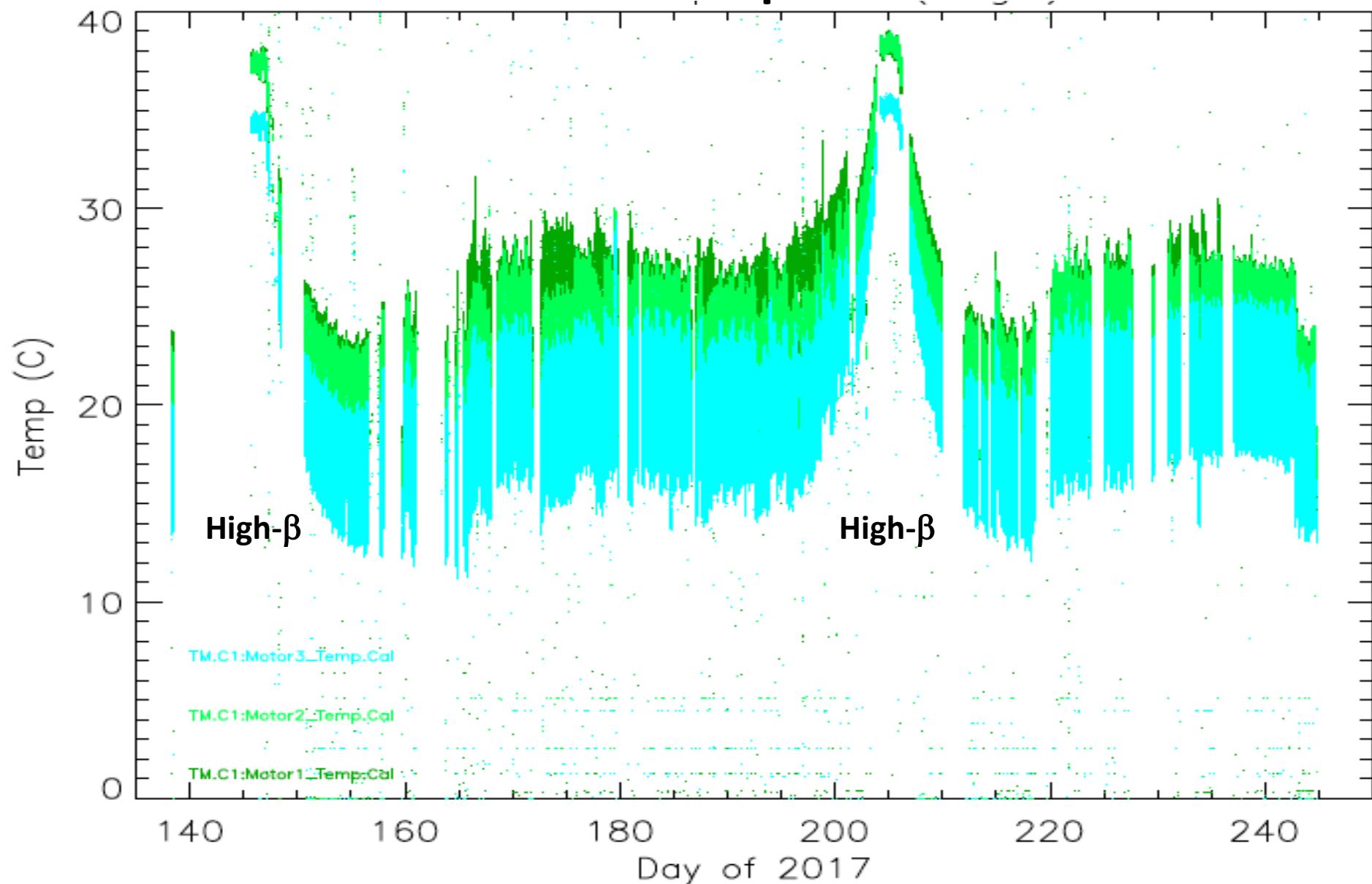
Motor Temperature

# Instrument Temperature
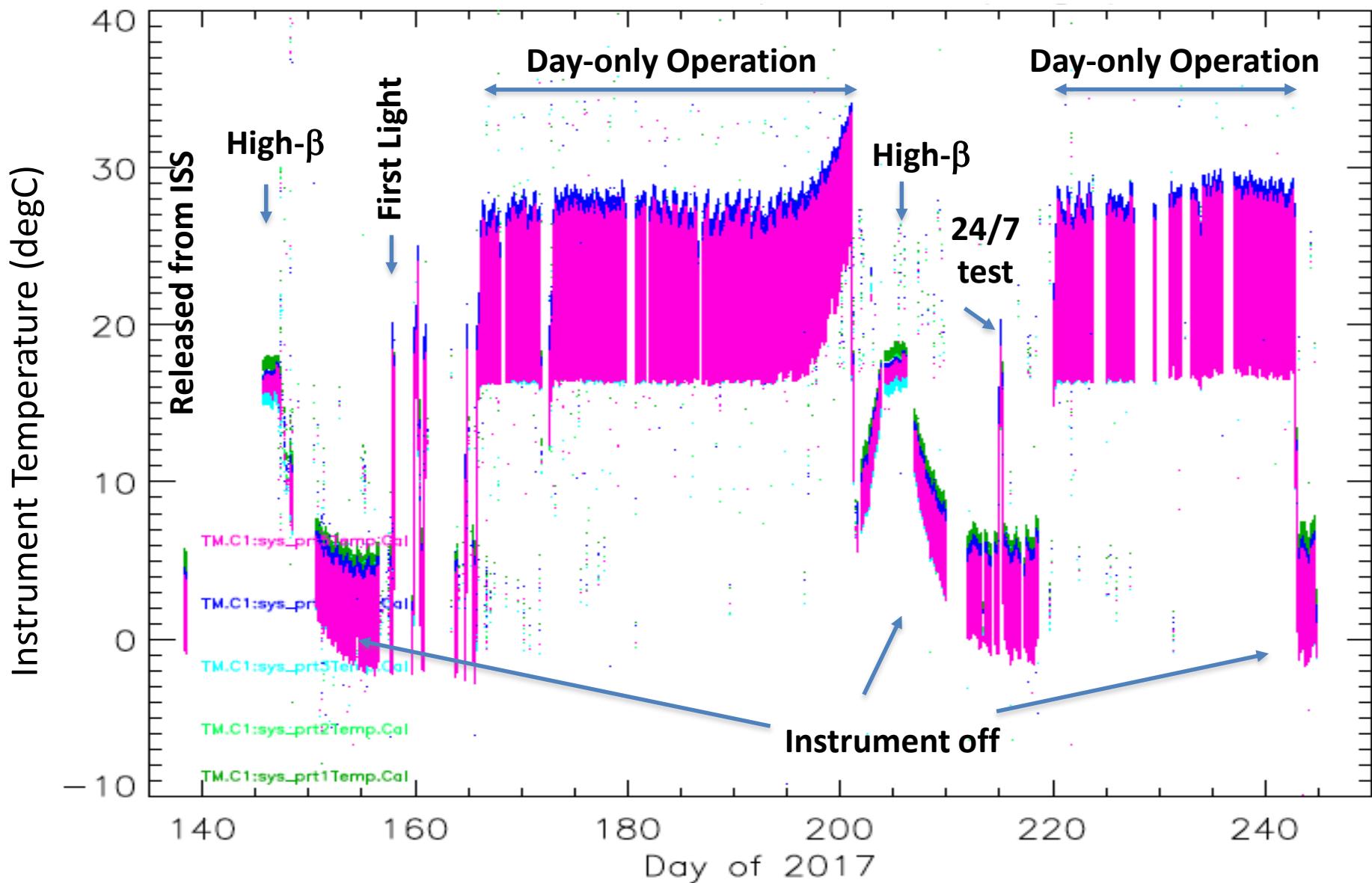
First Light from the 883-GHz Radiometer

June 6, 2017
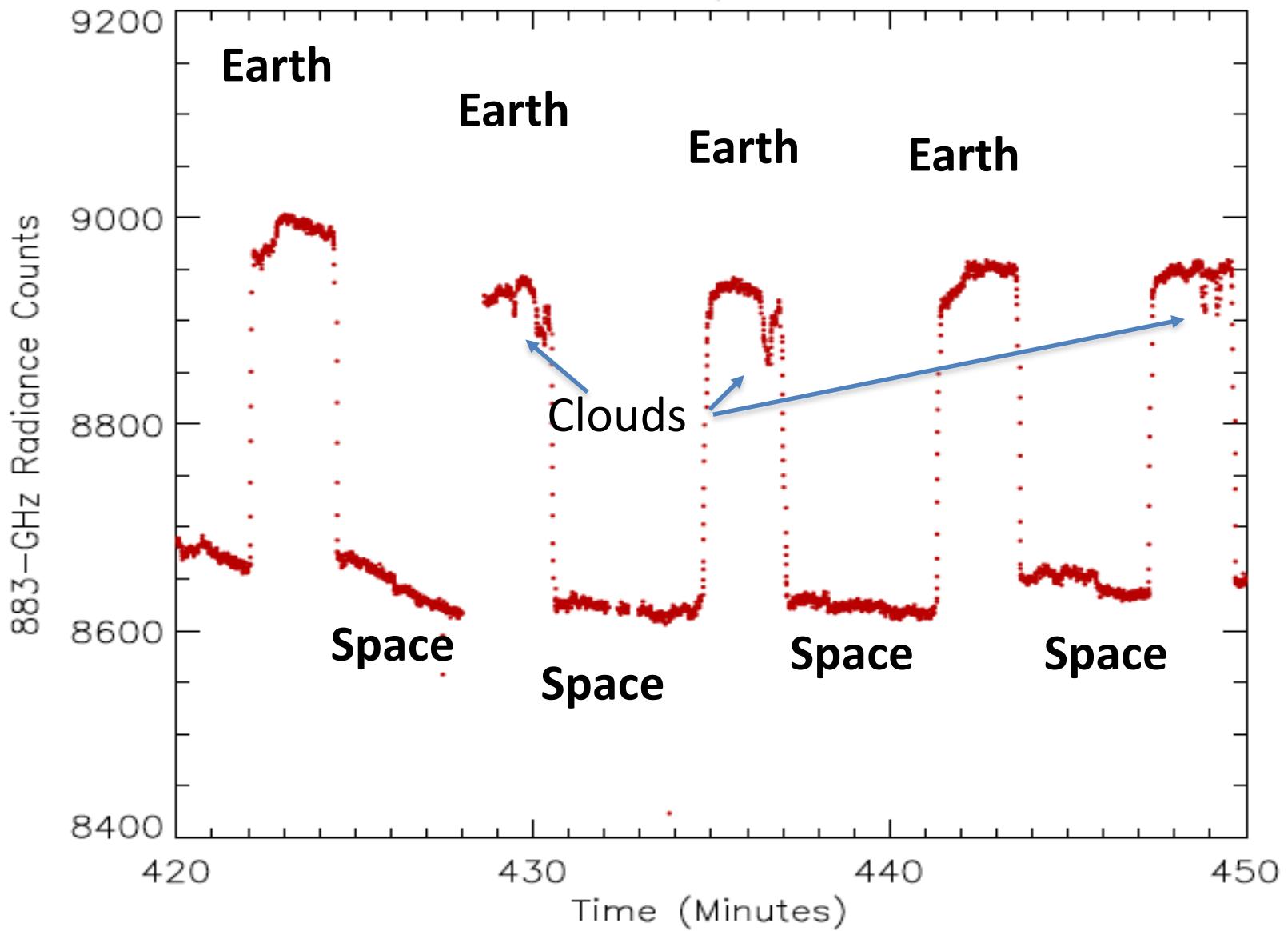
First Light Operation: Spin Rates


Night: Spin around geomagnetic field at **1.5 dps**

Day: Spin around sun vector at **-1.0 dps**
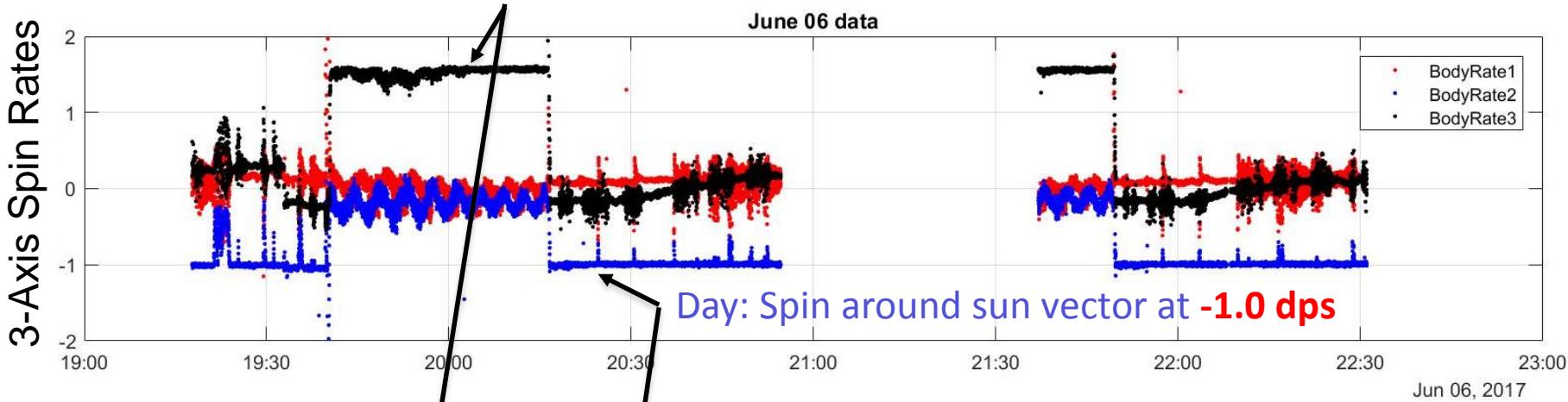
Day: Spin around sun vector at -1.0 dps
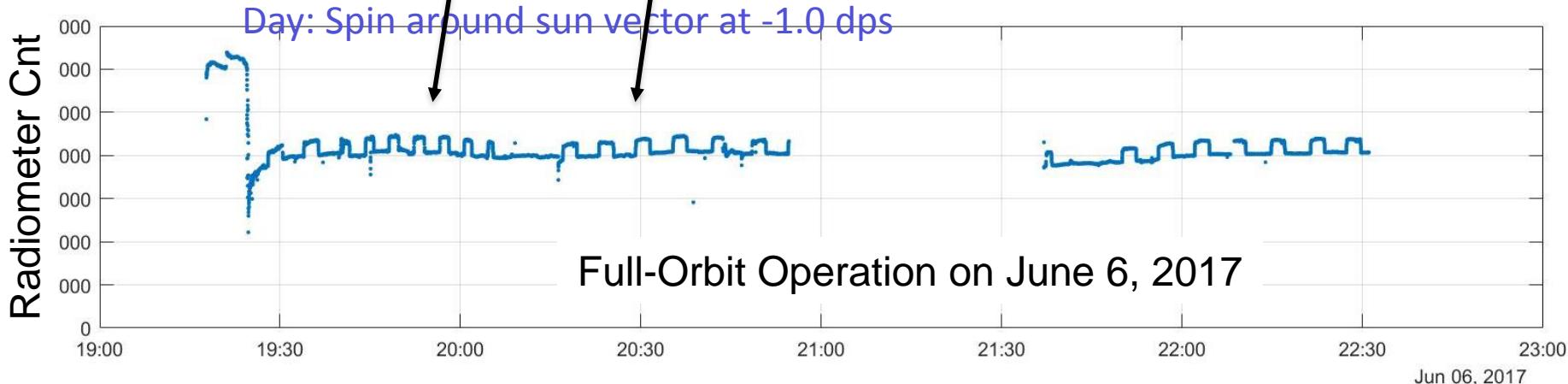
Full-Orbit Operation on June 6, 2017

Courtesy of Jon Bensman

Pointing: Limb-to-Limb Time

Spin Rate Errors

BCT/XACT spin rate biases!

$$\text{Ratio} = \frac{\text{Time\_Obs}}{\text{Time\_Sim}}$$

All data with angle from nadir < 20°
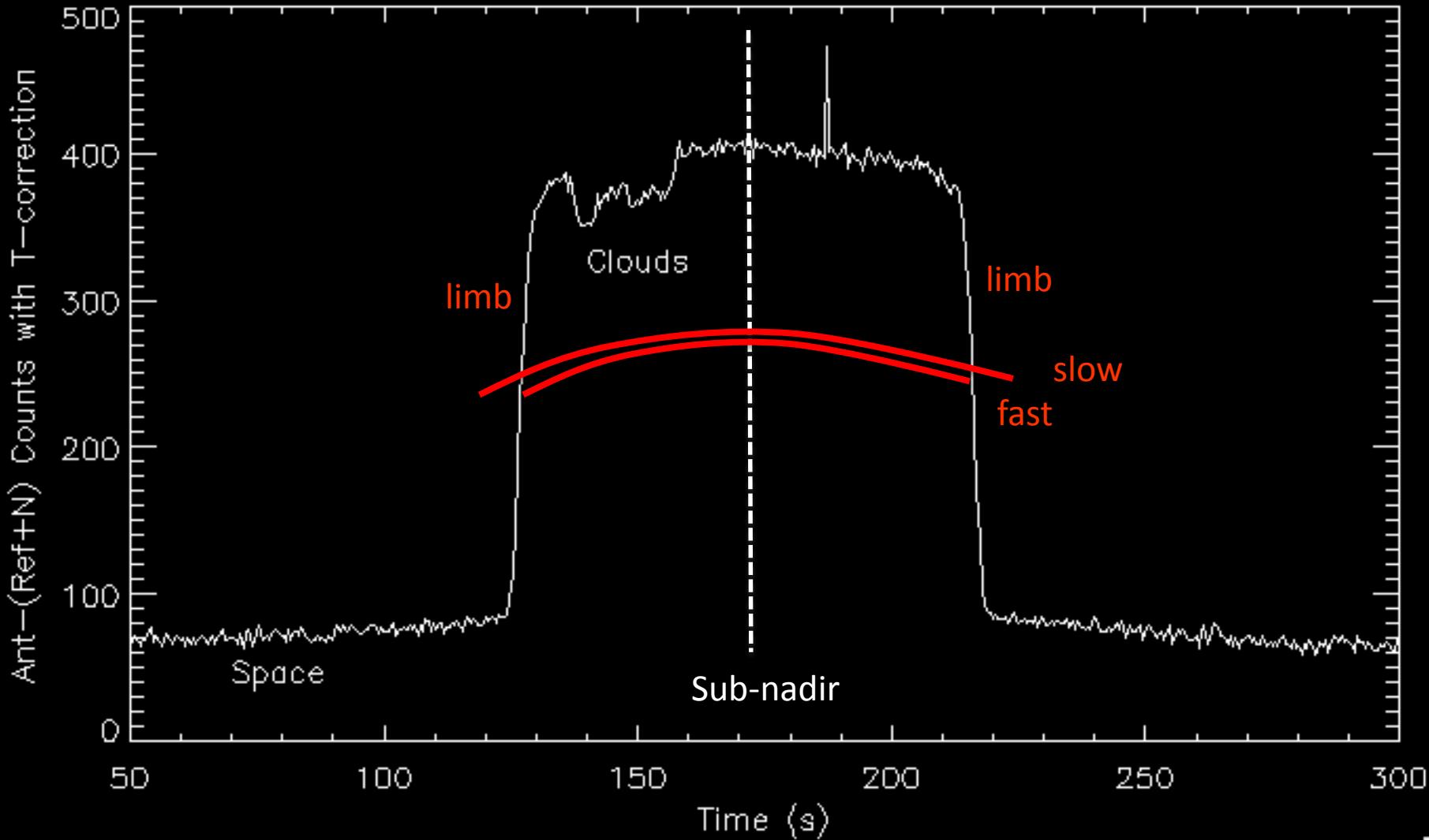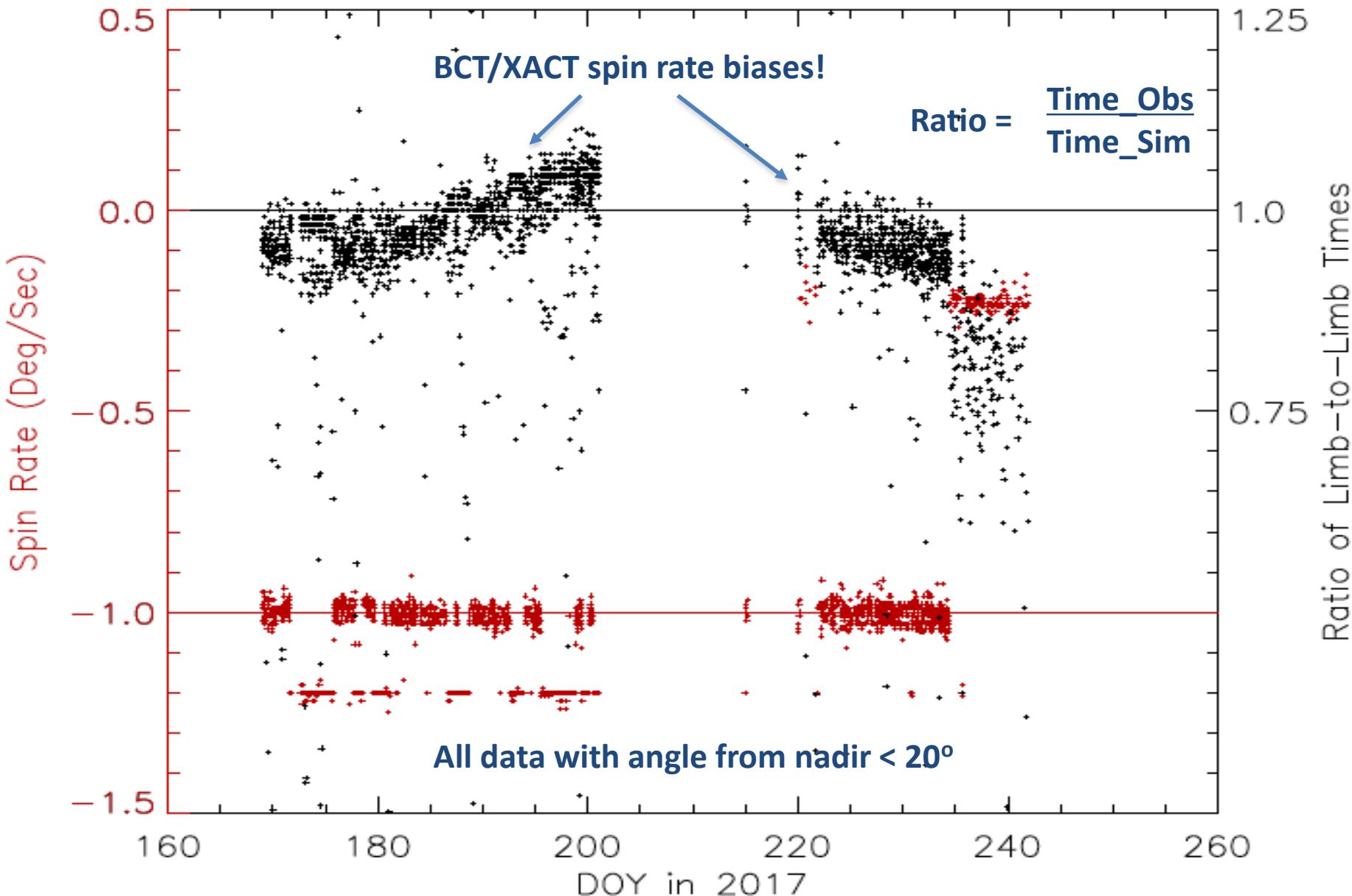
883-GHz Receiver Gain Model

(conversion from count to brightness temperature)

Temperature dependence (slope) is consistent
with TVAC measurements on the ground

$$G(T_p) = 1.73 - (T_p - 10)*0.023 \quad \text{cnt/K}$$
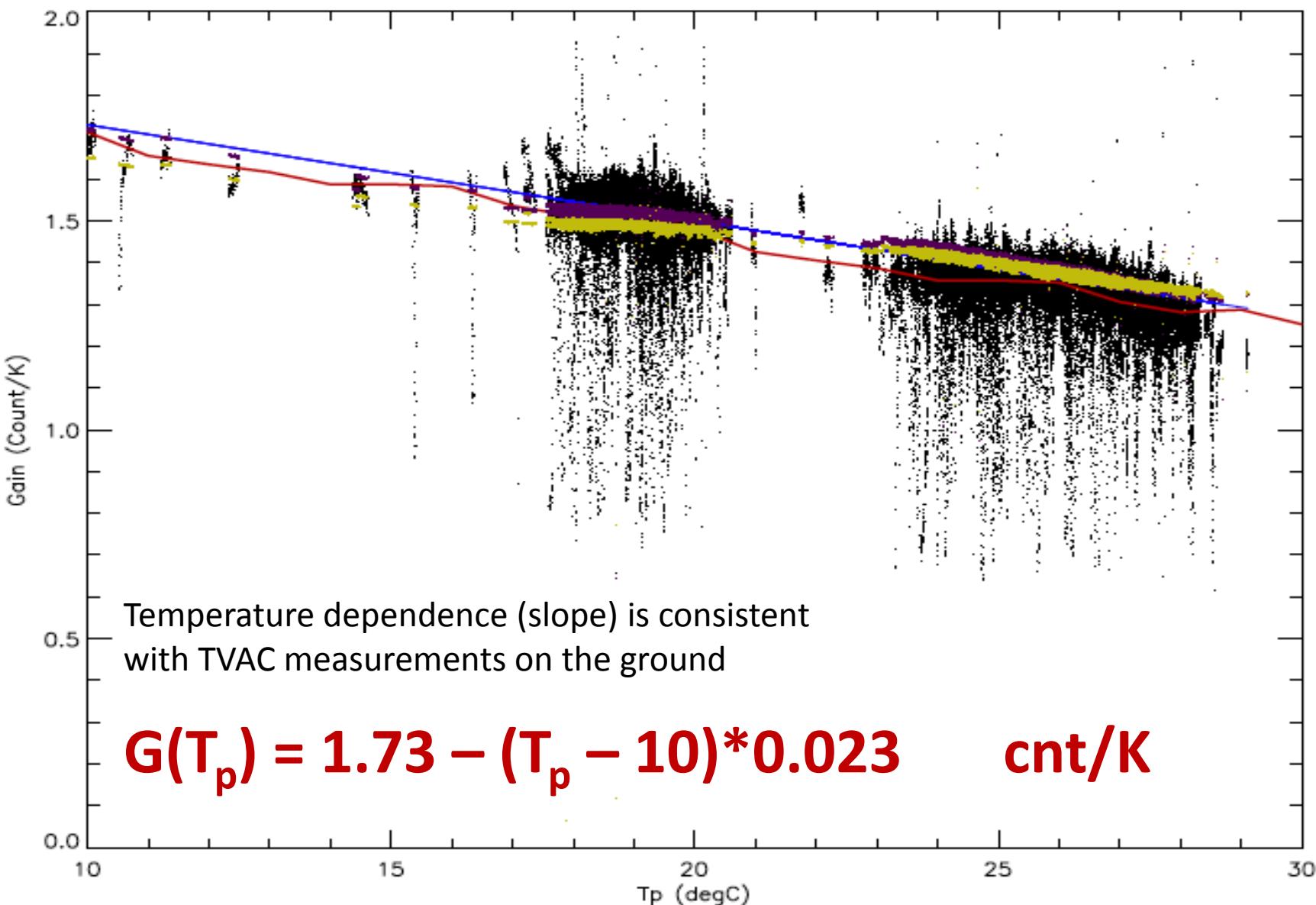
First 883-GHz Cloud Radiance Map

IceCube Cloud-Induced Radiance (Tcir) During 20170620 to 20170702
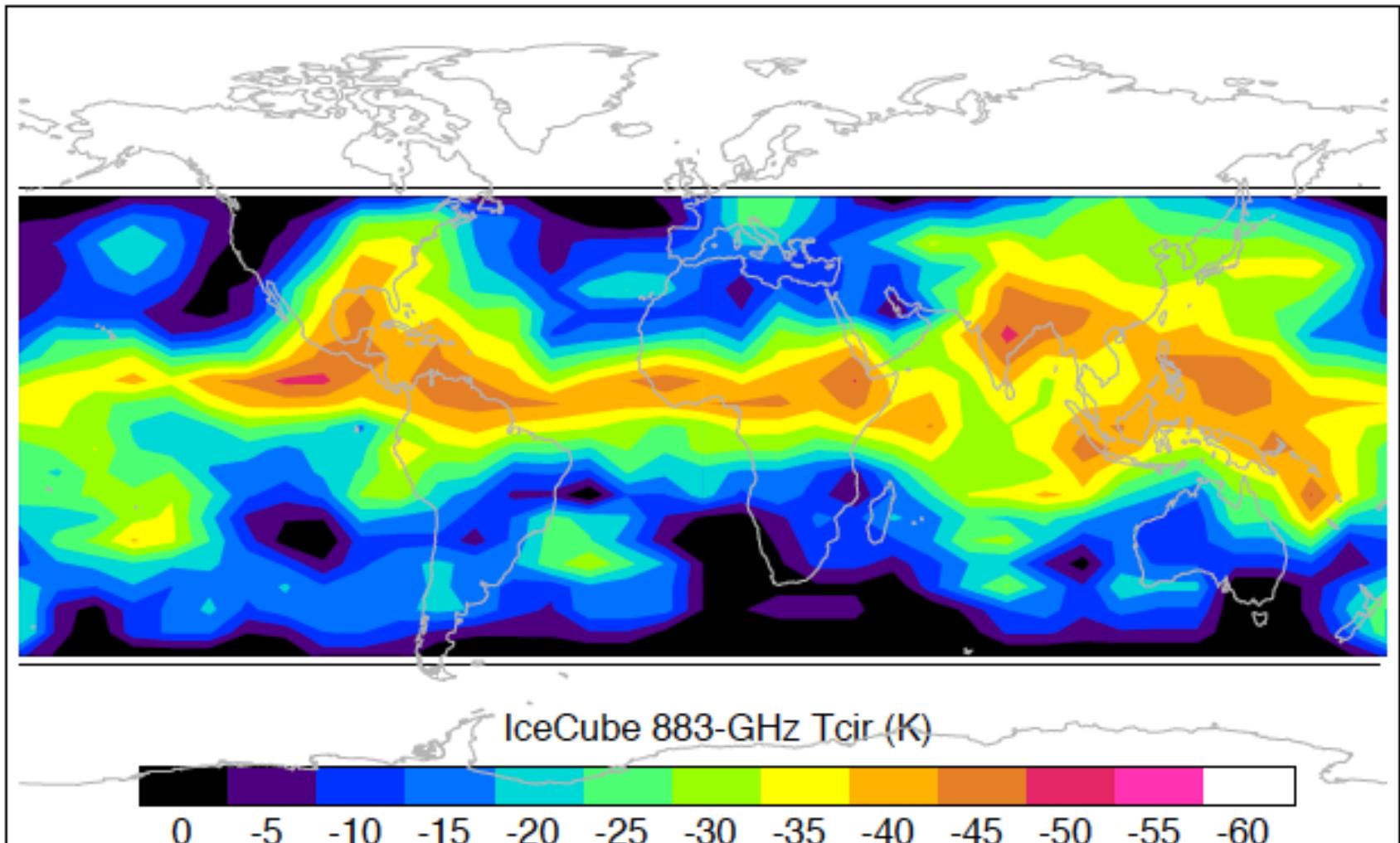
# SWIRP: Compact S̲ubmm-W̲ave and LW̲IR̲ P̲olarimeters

(An IIP-16 Project)

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Co-I Institutes: NGC, Univ of Arizona, TAMU

Particle Size Information for Cloud Ice

- Cloud-induced radiances (Tcir, from ice particle scattering) at 220, 680 GHz and 12 μm bands provide the wide dynamic range in sensitivity needed for measuring IWP > 5 g/m² and Deff > 30 μm.
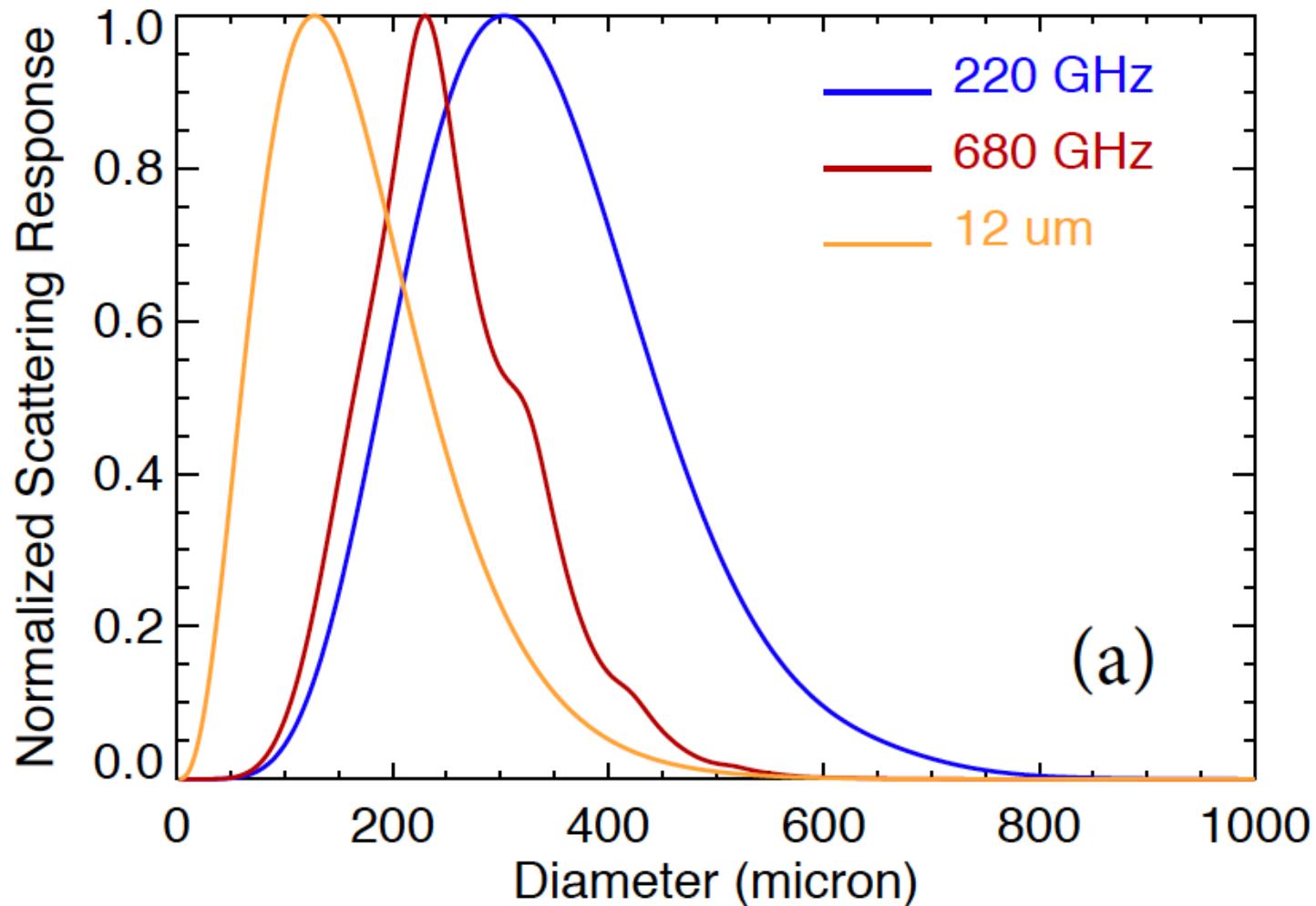
- Flight altitude 400km; Swath 700 km
- Conical scan rate: 17.6 rpm
- Integration time: 21.2 ms (220 GHz), 10.6 ms (680 GHz), 2.7 ms (11 μm)
- Submm primary reflector 3dB diameter : 6.7 cm
- Footprints/FOVs: 220 GHz (20 km /1.6°), : 680 GHz (10 km /0.8°), 11 μm (2.5 km/0.2°)
- Submm polarimetric receivers:
  – 680 GHz (V, H), 2x: direct detection (baseline), or heterodyne detection (backup)
 – 220 GHz (V, H), 1x direct detection
- LWIR polarimeter:
  – 3-band (8.6, 11, 12μm) channeled spectropolarimeter (baseline), or 2-band (11, 12μm) microgrid polarimeter (backup)
- Data rate: 22.3 kbps

(a) SWIRP Spatial Resolutions

Flight direction — Scan direction

LWIR image

10 km 8-12 μm 11μm (V,H)

10 km 8-12 μm 11μm (V,H)

10 km 680 GHz (V, H)

20 km 220 GHz V, H

10 km 680 GHz (V, H)

10 km / 10.6 ms

20 km / 21.2 ms

10 km /10.6 ms

(b)

45°

400 km

48.7°

Scan

Flight direction
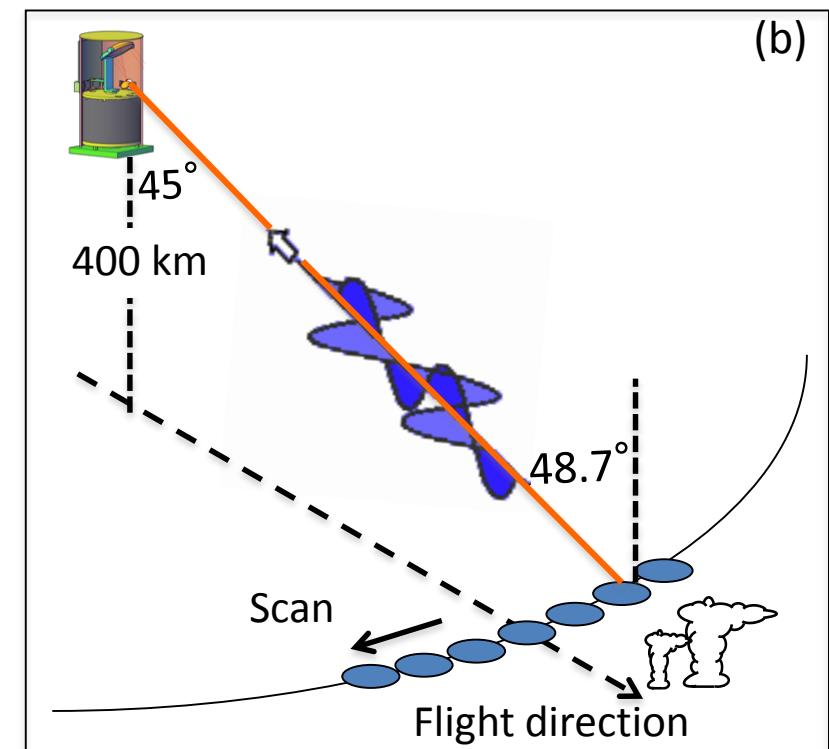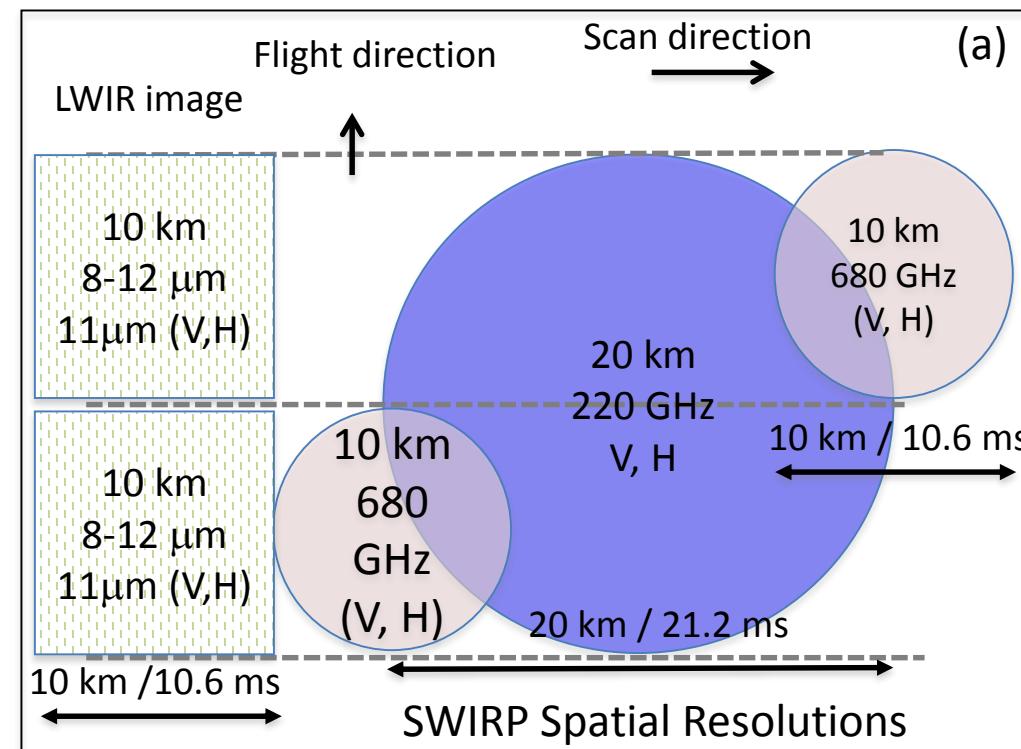
SWIRP Instrument

Main & Secondary FOV's